Two-Handed Volumetric Document Corpus Management

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Abstract

This paper describes a minimally immersive three-dimensional volumetric interactive information visualization system for management and analysis of document corpora. Two-handed interaction using three-space magnetic trackers and stereoscopic viewing are combined with glyph-based rendering of the corpora contents to produce a minimally immersive interactive system that enhances the user's three-dimensional perception of the information space. The results compare two-dimensional and three-dimensional techniques for information visualization

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Introduction

To find a document in the sea of information, one must embark on a search process, usually aided by computer. In the traditional *information retrieval* model, the final goal is to identify and collect a small number of documents to read in detail. In this case, a single query yielding a scalar indication of relevance is usually sufficient.

In contrast, *document corpus management* seeks to understand what is happening in the collection of documents as a whole (e.g., find relationships among documents). Individual documents may indeed be read or skimmed, but only to gain a greater understanding of the rest of the document set. Document corpus management seeks to identify trends, discover common linkages, and find clusters of similar documents. In this situation, the results of many single queries must be combined in various ways so that trends may be discovered. We describe a new system called the Stereoscopic Field Analyzer (SFA) that aids in the document corpus management task by employing 3D volumetric visualization techniques in a minimally-immersive real-time interaction style.

System Overview

Our system for minimally-immersive document corpus management is composed of two tightly-coupled components: the minimally-immersive visualization engine, SFA, and the document management and information retrieval engine, Telltale. Telltale [4] is a dynamic hypertext environment for text corpora that provides text indexing, management, and retrieval based on n-grams — n character sequences of text. Telltale provides document similarity measures (n-gram based m-dimensional vector inner-products) that are visualized by the SFA system for analyzing patterns and trends within the corpus. SFA allows the interactive visualization of these trends and similarities through the use of glyph-based volume visualization. Two-handed interaction within SFA allows interactive selection of documents for viewing and further analysis within the Telltale system.

In SFA, each document is represented by an icon or *glyph* that is located and shaded according to document attributes provided by Telltale, such as similarity measures. Six or more dimensions (attributes) of the information space can easily be visualized. The three-space location of each glyph allows the comparative display of three attributes. Glyph size and shape can easily encode two or more additional information attributes. The color of the glyph allows the independent display of one dimension, usually one in which high accuracy of perception is not needed. Additionally, opacity can be used for filtering attributes. Careful choice of glyph mappings is useful to identify trends and perceive important information from large information sets.

SFA Interface

With SFA, the user sits in front of a graphics console that has a screen, keyboard, mouse, stereo glasses, and a pair of six-degree-of-freedom (6DOF) magnetic trackers (*Bats*) that provide a two-handed minimally immersive interface, as shown in Figure 1(a). Each bat has three buttons glued onto the surface, as shown in Figure 1(b). The use of the Bat device allows the user to directly manipulate the 3D objects of interest without intermediate steps. We chose the minimally-immersive style because it does not isolate the user from accessing information on the desktop or from traditional I/O devices like the screen, keyboard, and mouse, especially important in text applications, while providing most of the advantages of immersive techniques.

The user interacts with 3D elements of the system by manipulating the two bats, and pressing bat buttons to invoke operations. Each bat has a distinct role, with the dominant hand being responsible for picking and manipulation, and the less-dominant hand being responsible for context setting of various kinds. Our system is ambidextrous, but for the sake of rhetorical convenience,

we will refer to the dominant hand as the right hand and the less-dominant hand as the left. The use of both hands improves spatial perception through the user's proprioception [3].

The left hand manipulates the position and orientation of the entire scene, and sets the drawing context from a hierarchical 3D tracker-based sundial menu [2]. The circular sundial puts each menu choice in its own pie-shaped sector, and left bat orientation controls the *shadow stick* selector to pick the desired item.

The right hand can select a 3D volume subset by sweeping out a 3D translucent box. To sweep, the user presses a right button to place one corner of the volume to be displayed, drags the right bat to the opposite corner, then releases the button, automatically culling the glyphs inside or outside of this box (user selectable). As the selection box is being swept out, the front and back walls are drawn as translucent rectangles so that the user can see what glyphs are being selected.

The right hand can also select a single glyph by pointing a laser-like probe into the volume. The glyph closest to the probe has its value printed and passed through a socket connection to the Telltale system, which displays the corresponding document. The document ID is also displayed in the 3D scene using screen-aligned text at the glyph, and at the corresponding 2D locations on each of the boundary walls of the volume. The probe, represented by a narrow cylindrical shaft, is attached to the right cursor, and the user controls the position and orientation of the probe with the right bat.

Results

Using Telltale output, we compared our visualization techniques to two-dimensional techniques used by the IVEE system [1]. The document corpus utilized was 1833 articles from the *Wall Street Journal* from September 18, 1989 to October 13, 1989. Document similarities to the following "thematic" articles were generated: Manuel Noriega[1], Federal Reserve Bank, foreign exchange rate, and gold prices. Figures 2a and 2b show the results from each system. In Figure 2a, similarity to gold, foreign exchange rate, and Federal Reserve Bank were respectively mapped to the X axis, Y axis, and to color. Initial analysis of the figure does not reveal the relationship between the themes of gold price and foreign exchange rate within articles in this corpus. The figure does show a relationship between the themes of foreign exchange rate and Federal Reserve Bank. For the visualization shown in Figure 2b, similarity to gold, foreign exchange rate, and Federal Reserve Bank were respectively mapped to the X axis, Y axis, and Z axis location of each document glyph. Glyph color represents article date, ranging from blue (oldest) to red (most current). Glyph shape represents similarity to Noriega with cubes depicting little similarity and cones greatest similarity. Figure 2b clearly shows the most relevant 40 documents to these themes out of this large corpus. This figure also clearly shows two binary relationships among several articles: the relationship between the themes of foreign exchange rate and Federal Reserve Bank (left data branch) and the relationship between the themes of gold price and foreign exchange rate (right data branch). Finally, this figure shows that there is only 1 document discussing the effect of the coup attempt against Noriega on the price of gold (upper right cone in the figure).

These initial results show that volume visualization and interactive stereoscopic manipulation of some data sets can highlight the similarities of topics better than 2D visualization. Volume visualization is better at representing trinary relationships because spatialization is a more significant visual cue than color. Glyphs are also a valuable tool for visualization of large corpora because

[1] A coup attempt in Panama to overthrow Noriega occurred during this time period.

of the improved spatialization compared to two-dimensional techniques. More rigorous studies are needed to fully characterize the relative advantages of 2D and 3D techniques for information visualization.

Conclusion

These visualizations have shown how realtime two-handed interactive volume visualization of document corpora can quickly convey trends and multi-dimensional relationships among the information data. Careful attribute mapping and interactive volume culling can be used for quick elimination of useless data, allowing better analysis of the most interesting information. From our experience, the two-handed interaction metaphor is a natural way to interact with volumetric data, and a naive user can become comfortable and proficient using the system within 10 minutes. The current system permits interactive picking of document glyphs, allowing the retrieval of the document text in the Telltale system for further exploration. SFA provides great flexibility in information mapping for improved perception of relationships and also allows for the real-time interaction, navigation, manipulation, and increased understanding of large time-varying multivariate information spaces.

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Figure 1: (a) A user using the two-handed stereo interface to SFA.(b) A 3D tracker with buttons attached.

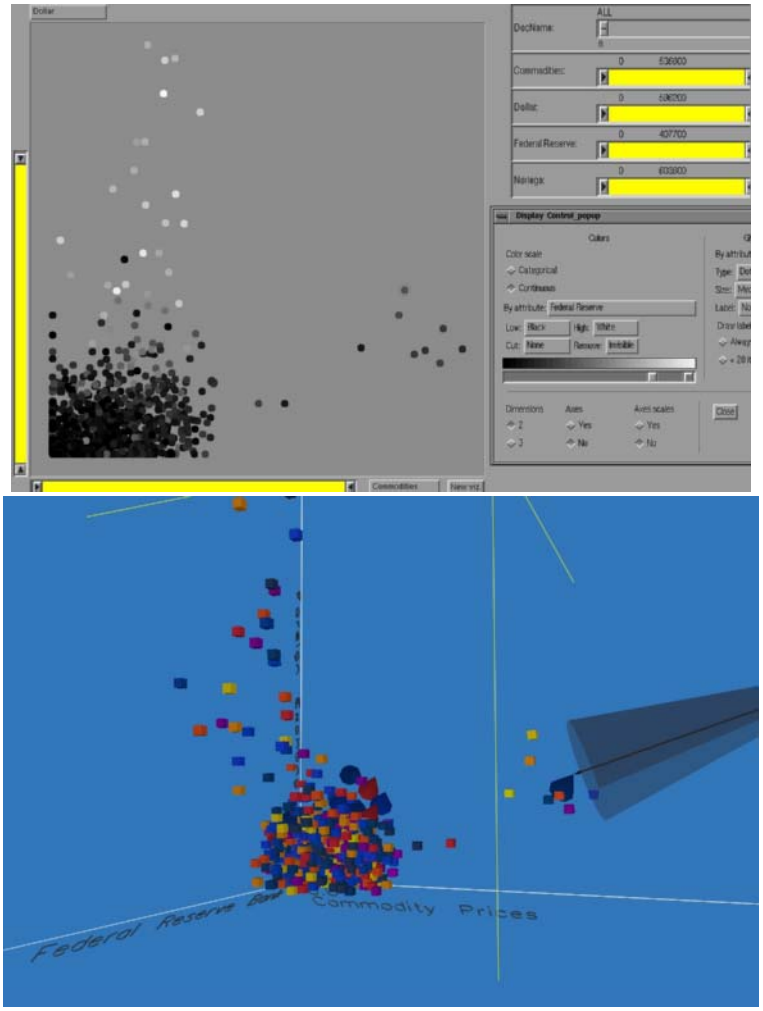

Figure 2: (a) Two-dimensional visualization of 1833 documents' relationship to commodity prices, foreign exchange, and the federal reserve using the IVEE system. (b)Three-dimensional visualization of 1833 documents' relationship to commodity prices, foreign exchange, and the federal reserve using SFA. The probe is selecting one article.